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Hawaii-Grown Grain Sorghum: A Source of Dietary Energy for Laying White Leghorn Pullets

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DISCLAIMER

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ABSTRACT

Two hundred fifty 20-week-old Single-Comb White Leghorn (Hy-Line) pullets were used to study the replacement value of Hawaii-grown grain sorghum over corn, on a weight for weight basis (w/w), on performances from 20 to 60 weeks of age.

Hawaii-grown grain sorghum was determined satisfactory as a replacement for commercial corn in layer diets. Pullets fed sorghum, corn, or sorghum and corn as the source of grain in their diets did not significantly differ in livability or age at 50 percent egg production. On the other hand, pullets fed standard diets in which sorghum replaced corn were significantly lighter in weight at 60 weeks of age. Pullets fed sorghum, corn, or sorghum and corn did not significantly differ in feed consumption during the 40-week test period. There was a trend toward an increase in feed consumption as the dietary sorghum level was increased. During the test period, pullets fed a combination of 50 percent sorghum and 50 percent corn produced significantly more eggs than those fed 100 percent corn. Feed efficiency of pullets fed sorghum, corn, or sorghum and corn (w/w) did not significantly differ. Amounts of feed consumed per egg produced were 146.5, 148.0, 145.4, 153.0, and 155.4 grams (g), respectively, for birds fed 0, 25, 50, 75, and 100 percent sorghum as a replacement for corn. There was a slight trend toward a larger egg size by birds fed the sorghum diet. This difference in egg size, however, was not statistically significant.

INTRODUCTION

Hawaii's poultry industry is wholly dependent on imported grains, and there is a great need for studies on ways and means of relieving this dependence. The production of more economical feed ingredients has long been important. Grain sorghum was considered a possibility because of its geographical flexibility, low-moisture requirements, and early maturity. Also, the price of sorghum is often considerably lower than corn.

REVIEW OF LITERATURE

Adolph and Grau (1956) reported that the performance of layers was not significantly different when fed diets containing predominantly sorghum or corn. Berry (1958) found no significant difference in egg production among hens housed in individual cages and fed corn, sorghum, or corn and sorghum. He noted that, because the protein levels of the diets were not kept equal, the all-sorghum diet, with its higher protein level, had an advantage over the corn diet. Malik and Quisenberry (1963) observed that when the cereal grain consisted of corn, sorghum, or corn and sorghum, birds receiving diets of (1) 100 percent corn and (2) 50 percent corn and 50 percent sorghum laid significantly more eggs than those receiving (3) 25 percent corn and 75 percent sorghum and (4) 100 percent sorghum. Further, birds receiving diets of 100, 75, or 50 percent corn as the cereal grain laid significantly larger eggs and required less feed per unit of egg than those receiving diets containing either 100 percent or 75 percent sorghum as the grain.

Quisenberry et al. (1963) noted that eggs from pullets fed 18 percent protein diets differed in size as a result of the cereal grain in the diet. Eggs of birds fed high-corn diets weighed 60.0 g, whereas those of birds fed a high-sorghum diet weighed only 59.0 g. When the dietary protein was held at 15 percent, eggs of corn-fed birds weighed 59.1 g, while those of birds fed sorghum weighed 56.5 g. Bray (1964) found that a 55:45 combination of soybean and corn protein supported higher egg yields than the same combination of soybean and sorghum protein, but this difference was negated in the presence of supplemental DL-methionine. Deaton and Quisenberry (1964) reported that birds receiving sorghum diets containing either 14 percent or 16 percent protein laid smaller eggs than those receiving corn with the same concentration of protein. Deaton and Quisenberry (1965) observed that laying hens improved in performance when the sorghum-soybean diet was supplemented with amino acids, whereas no improvement was noted with the corn-soybean diet with amino acid supplementation. Deaton and Quisenberry (1967) confirmed their earlier works (1964, 1965) that grain sorghum could not be substituted for all the corn in the laying diet without significantly lowering performance.

Halloran and Maunder (1971) reported that birds fed diets containing red (normal), yellow, and bronze sorghums showed no significant differences in egg production. Feed conversion was better for the diets containing red sorghum than for those containing corn. Sanford (1972) found that egg production of birds fed yellow corn was highest, followed by egg production of birds fed wheat, ordinary grain sorghum, and yellow endosperm sorghum. Weber et al. (1972) found that egg production of sorghum-fed birds did not significantly differ from that of birds fed corn or triticale. Palafox (1974) reported that Hawaii-grown grain sorghum was as good as corn for broiler chicks.

The experiment reported in this bulletin was conducted to compare the production performances of laying pullets fed either Hawaii-grown grain sorghum or commercial corn, or various combinations of both.

EXPERIMENTAL PROCEDURE

Two hundred fifty Single-Comb White Leghorn (Hy-Line) pullets were randomly distributed into 25 groups of 10 birds each. Five replicate groups were assigned to each of five treatments. Each bird occupied an all-wire 25- × 46-cm laying cage in a 7.32- × 12.19-m laying house, enclosed on two sides with 1.27- × 1.27-cm wire mesh cloth. The birds were fed 0, 15.90, 31.80, 47.70, or 63.60 percent grain sorghum as a replacement for commercial corn in the total diet. Feed and water were provided ad libitum. The diets were fed in a randomized block design. Table 1 shows the diet composition.

Data were obtained daily on egg production and every 4 weeks on feed consumption. Egg collections for 3 consecutive days per week

Table 1. Composition of layer diets

Ingredient	Diet[1] 708 (S = 0%, C = 100%)	709 (S = 25%, C = 75%)	710 (S = 50%, C = 50%)	711 (S = 75%, C = 25%)	712 (S = 100%, C = 0%)
	%				
Sorghum	0.00	15.90	31.80	47.70	63.60
Corn	63.60	47.70	31.80	15.90	0.00
Tallow	0.25	0.25	0.25	0.25	0.25
Oats	5.00	5.00	5.00	5.00	5.00
Soybean meal (44%)	16.70	16.70	16.70	16.70	16.70
Tuna meal (54%)	3.00	3.00	3.00	3.00	3.00
Alfalfa meal (17%)	3.00	3.00	3.00	3.00	3.00
Oyster shell	2.72	2.72	2.72	2.72	2.72
Limestone	4.00	4.00	4.00	4.00	4.00
Tricalcium phosphate	0.82	0.82	0.82	0.82	0.82
Premix R_3[2]	0.25	0.25	0.25	0.25	0.25
DL-methionine	0.25	0.25	0.25	0.25	0.25
Lysine HCl	0.01	0.01	0.01	0.01	0.01
Salt	0.40	0.40	0.40	0.40	0.40
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
Protein, %	15.65	15.81	15.96	16.12	16.27
Metabolizeable energy/ kg, kcal	2825	2797	2768	2740	2711

[1]Proportion of corn (C) and sorghum (S) in the diet.
[2]Premix R_3 provided per kg diet: 881.8 U.S.P. units vitamin A, 220.5 I.C.U. vitamin D_3, 8.3 I.U. vitamin E, 0.16 mg riboflavin, 0.04 mg thiamine, 0.29 mg d-pantothenic acid, 1.17 mg niacin, 440.9 mg choline chloride, 0.11 mg vitamin B_{12}, 0.33 mg folic acid, 2.20 mg menadione bisulfite, 0.12 g B.H.T., 0.06 g Mn, 0.04 g Fe, 0.004 g Cu, 0.0009 g I, and 0.0002 g Co.

were run through a commercial egg grader when birds were from 35 to 40 weeks of age, inclusive. Body weight at age 20, 36, 48, and 60 weeks, number of birds living at age 36, 48, and 60 weeks, and number of days at which each group of birds first laid at a rate of 50 percent or more were also recorded. An analysis of variance was run on the data, using the residuals as the error term. Significant differences between means were located by using Duncan's (1955) multiple range test.

Body Weight

Table 2 shows body weight data. As expected, the 20-week initial weight was similar among treatment groups. At 36 weeks of age, grain sorghum in the diet did not significantly affect body weight. However, final body weight at 60 weeks was significantly affected. Pullets fed diets in which sorghum replaced 100 percent of the corn (diet 712) were significantly lighter than those fed only corn (diet 708). Differences in body weight among other lots were small and not statistically significant. Sorghum, therefore, was used to replace up to 75 percent of the corn in the diet of pullets aged 20 to 60 weeks without significantly affecting final body weight.

Livability

Grain sorghum in the layer diet did not affect livability (Table 2). Livability was lowest (94 percent) among the lots in which 25 percent of the corn was replaced by sorghum. All other lots were the same at 98 percent.

Sexual Maturity

Age at sexual maturity also was not significantly affected by grain sorghum in the diet (Table 2). Age at 50 percent egg production had a total range of only 167.8 to 170.8 days.

Table 2. Body weight, livability, and sexual maturity[1]

	Diet[2]				
Age, weeks	**708 (S = 0%, C = 100%)**	**709 (S = 25%, C = 75%)**	**710 (S = 50%, C = 50%)**	**711 (S = 75%, C = 25%)**	**712 (S = 100%, C = 0%)**
Body weight (g)					
20 (initial weight)	1346	1362	1369	1388	1314
36	1618	1659	1602	1650	1594
48	1617	1687	1653	1695	1623
60 (final weight)	1695a	1684a	1639ab	1675a	1589b
Livability (%)					
20–36	100	98	98	100	100
20–48	100	96	98	98	98
20–60	98	94	98	98	98
Sexual maturity (days)					
Age at 50% egg production	168.2	167.8	170.0	168.0	170.8

[1]Means on the same horizontal line bearing different letters are significantly different ($P < 0.05$).

[2]Proportion of corn (C) and sorghum (S) in the diet.

Table 3. Daily feed consumption[1]

Age, weeks	Diet[2]				
	708 (S = 0%, C = 100%)	709 (S = 25%, C = 75%)	710 (S = 50%, C = 50%)	711 (S = 75%, C = 25%)	712 (S = 100%, C = 0%)
	g				
20–24	68.3c	74.2b	69.8c	76.6b	81.6a
24–28	93.1b	96.7ab	96.4ab	100.1a	101.0a
28–32	103.0	103.6	102.6	107.6	103.9
32–36	106.1	106.3	105.2	110.2	113.0
36–40	108.1	108.3	110.6	120.2	108.5
40–44	108.7	112.1	112.0	117.1	112.1
44–48	106.3b	109.2b	112.3ab	114.2ab	121.9a
48–52	108.2	109.5	110.0	110.4	117.1
52–56	106.4	106.6	104.0	112.5	115.5
56–60	104.6	106.7	110.5	112.5	114.5
20–60 (average)	100.7	103.7	105.6	105.6	110.9

[1]Means on the same horizontal line bearing different letters are significantly different ($P < 0.05$).

[2]Proportion of corn (C) and sorghum (S) in the diet.

Feed Consumption

Table 3 shows the daily feed consumption. Substituting graded levels of grain sorghum seemed to increase feed intake in a linear pattern during the periods 20–24, 20–28, and 44–48 weeks of age. It is not clear why feed intake differences due to sorghum level were inconsistent and not significant between 28 and 44 weeks of age, or between 44 and 60. It was expected that a somewhat greater feed intake would result from a lower energy concentration in the diet, but such an adjustment should be greater as the bird had more time to adjust capacity. It appears from feed intake, body weight, and production that compensation for lowered energy content in the diet due to sorghum did not continue. During the entire period, feed consumption per bird did tend to increase as the amount of sorghum in the diet increased. These differences in means were not statistically significant.

Egg Production

The experiment was conducted on birds 20 to 60 weeks of age. It was not possible to extend the experiment beyond 60 weeks of age because of the limited amount of Hawaii-grown grain sorghum. Table

Table 4. Hen-day egg production[1]

Age, weeks	Diet[2]				
	708 (S = 0%, C = 100%)	709 (S = 25%, C = 75%)	710 (S = 50%, C = 50%)	711 (S = 75%, C = 25%)	712 (S = 100%, C = 0%)
	%				
20–24	27.00	30.00	26.57	25.88	23.36
24–28	72.06ab	72.61a	72.21ab	71.71b	69.35b
28–32	71.00	71.67	70.57	73.64	68.86
32–36	70.07	70.77	72.04	71.02	73.78
36–40	72.17	71.50	74.33	72.23	69.50
40–44	71.28	72.18	76.17	75.44	78.06
44–48	68.00b	71.91ab	75.68a	75.54a	76.16a
48–52	67.21	68.76	74.12	69.65	74.14
51–56	68.14ab	62.45b	73.16a	66.73ab	72.53a
56–60	62.64	65.29	70.17	65.71	66.59
20–60 (average)	64.36b	66.17ab	70.17a	65.56ab	67.23ab

[1]Means on the same horizontal line bearing different letters are significantly different ($P < 0.05$).
[2]Proportion of corn (C) and sorghum (S) in the diet.

4 shows the hen-day egg production from 20 to 60 weeks of age. During the 40-week test period, treatment significantly affected egg production. Pullets fed the diet containing 100 percent corn (diet 708) produced fewer eggs ($P < 0.05$) than those fed the diet in which 50 percent of the corn was replaced by sorghum (diet 710). Differences in egg production in diets other than the 50 percent replacement of corn by sorghum (diets 708, 709, 711, and 712) were not statistically significant. Significant differences in egg production due to treatment were found only during the periods 24–28, 44–48, and 52–56 weeks of age. These differences, when related to level of sorghum in the diet, were inconsistent.

When the entire test period is considered, there appears to be a slight advantage in using a mixture of corn and sorghum. The variation in production of different lots by periods makes it difficult, however, to define an optimum ratio. It does, however, indicate that sorghum was successfully used to replace corn in the diet of laying pullets. The preceding observations are consistent with those of Adolph and Grau (1956) who found that the performance of layers was not significantly different when fed diets containing predominantly either sorghum or corn.

Table 5. Feed consumed per egg produced[1]

Age, weeks	Diet[2] 708 (S = 0%, C = 100%)	709 (S = 25%, C = 75%)	710 (S = 50%, C = 50%)	711 (S = 75%, C = 25%)	712 (S = 100%, C = 0%)
			g		
20–24	257.9b	251.8b	276.6ab	302.4ab	361.3a
24–28	129.5b	126.4b	133.5b	143.8a	146.3a
28–32	145.5	145.8	145.3	146.3	151.7
32–36	152.3	150.6	146.9	155.3	153.7
36–40	150.1	152.1	148.8	167.1	157.7
40–44	153.0ab	155.3a	146.9ab	155.5a	143.1b
44–48	156.8	152.2	148.8	151.1	160.0
48–52	161.7	159.3	148.8	158.8	158.1
52–56	156.8ab	172.2a	142.2b	169.2a	159.2ab
56–60	167.3	163.7	157.5	171.7	172.5
20–60 (average)	146.5	148.0	145.4	153.0	155.4

[1]Means on the same horizontal line bearing different letters are significantly different ($P < 0.05$).

[2]Proportion of corn (C) and sorghum (S) in the diet.

Feed Efficiency

Feed consumed per egg produced (feed efficiency) is recorded in Table 5. There were no significant differences in feed efficiency as a result of the level of sorghum in the diet during the total test period. During the period 20–24 weeks, pullets fed diets in which sorghum replaced 0, 25, and 50 percent of the corn (diets 708, 709, and 710) were more efficient ($P < 0.05$) than those fed diets in which 75 or 100 percent of the corn was replaced by sorghum (diets 711 and 712). Over the entire test period, there was a trend toward increasing feed consumption per unit of egg as the amount of grain sorghum was increased. Pullets fed sorghum as a replacement for all the corn (diet 712) consumed 8.9 g more feed per egg produced than those fed the diet containing no sorghum (diet 708). These differences were not statistically significant.

Egg Size

Table 6 shows egg size data. There was no real difference in egg size due to the level of sorghum in the diet. The only significance found was a slightly higher number of medium-sized eggs at 38 weeks from birds

Table 6. Effect of grain sorghum on egg size

Age, weeks	Diet[1] 708 (S = 0%, C = 100%)	709 (S = 25%, C = 75%)	710 (S = 50%, C = 50%)	711 (S = 75%, C = 25%)	712 (S = 100%, C = 0%)
	%				
Medium[2]					
35–40 (average)[3]	4.12	1.35	1.01	1.54	2.47
Large[2]					
35–40 (average)[3]	33.29	32.14	28.38	22.81	24.82
Extra large[2]					
35–40 (average)[3]	62.59	66.51	70.61	75.65	72.71
Large plus extra large[2]					
35–40 (average)[3]	95.88	98.65	98.99	98.46	97.53

[1]Proportion of corn (C) and sorghum (S) in the diet.
[2]Medium 47–53 g, large 54–60 g, extra large 61–68 g, and jumbo 69 g and over.
[3]Average of 6 weeks data (3 consecutive days per week).

fed the all-corn diet. Since this significance did not carry through to other periods, it was not considered real. There may have been a trend toward larger egg sizes from birds on the higher sorghum diets, probably as a result of higher protein in the sorghum.

CONCLUSION

Hawaii-grown grain sorghum was as good or better than commercial corn weight for weight (w/w) for efficient performance of laying pullets.

Single copies of this publication available without charge to **Hawaii residents** from county agents. **Out-of-State** inquiries or **bulk orders** should be sent to the College of Tropical Agriculture Order Desk, Room 108 Krauss Hall, 2500 Dole Street, Honolulu, Hawaii 96822. Price per copy to bulk users, thirty cents plus postage.

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